# NAVAL POSTGRADUATE SCHOOL
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# THESIS

**DEVELOPMENT AND APPLICATION OF A MULTIMEDIA ASSESSMENT TOOL**

by

Daniel E. Nixon

March, 1997

Thesis Co-Advisors: Anthony Ciavarelli
William Haga

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**DEVELOPMENT AND APPLICATION OF A MULTIMEDIA ASSESSMENT TOOL**


Daniel E. Nixon
Lieutenant, United States Navy
B.A., Auburn University, 1988


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Author: Daniel Edward Nixon
Daniel E. Nixon

Approved by: Anthony Ciavarelli
Anthony Ciavarelli, Co-Advisor

William Haga
William Haga, Co-Advisor

Gail Fann Thomas
Reuben Harris, Chairman
Department of Systems Management

# ABSTRACT

In the Naval Aviation community, interactive, multimedia computer-based training is being explored as a cost-effective alternative to traditional modes of training. This thesis develops an assessment tool for multimedia systems to be used in computer-based training by combining performance recommendations for multimedia hardware and software. It delivers a checklist for multimedia developers to assess the capability of proposed multimedia training systems.

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# I. INTRODUCTION

## A. PURPOSE

The Aviation Safety School at the Naval Postgraduate School is under contract by Naval Air Systems Command to develop a computer-based training application for the AN/AVS Aviators Night Imaging System/Heads Up Display (ANVIS/HUD). This system is a combination of night vision goggles (NVG) and a heads-up display (HUD) system that will ultimately be installed in the Navy's 1553 data-bus configured rotary wing aircraft. Computer -based trainers have been developed for both the UH-1N Huey and the HH-60H helicopter trainer.

The Aviation Safety School is also interested in developing multimedia computer systems that will enhance the effectiveness of the computer-based training, by increasing the realism and interactiveness, of the ANVIS/HUD training application.

With the decline in the amount of money available for the Navy in general and for training specifically, cheaper methods for maintaining combat readiness are being considered. Simulation through computers and computer-based training is one method to provide a more realistic training environment and reduce the amount of money spent on training. Procuring a system with a configuration that uses

multimedia to enhance the training is essential. There are no readily available guidelines available for assessing various multimedia devices.

The purpose of this research is to develop a methodology that will assist multimedia system developers or procurers in evaluating multimedia hardware and software for use in computer based training. A multimedia systems taxonomy will be developed for assessing and selecting multimedia equipment and software for use in computer-based training systems. A goal of this effort is to equip a computer-based trainer with a media environment that maximizes the learning experience.

The second purpose of this thesis is to assess the state of the art in multimedia hardware and software and to take a brief look at up and coming multimedia technologies.

An attempt will be made to produce a methodology in a user friendly format, such as a checklist, that will assist operational level personnel in obtaining a system capable of delivering adequate performance and give them a guideline for choosing multimedia enhancements to enrich the instructional experience.

## B. OBJECTIVES

The following tasks to be undertaken in order to accomplish the purposes as specified above are:

- Research the current state of the art in multimedia hardware and software configurations
- Research current multimedia performance standards and apply them to the taxonomy
- Research current benchmarking models and techniques and apply them to the taxonomy
- Research current multimedia frameworks

## C. BACKGROUND

In a Night Vision Goggle (NVG) training technology report done for the Naval Air Systems Command (PMA 205) by the Naval Postgraduate School in December 1994, a need to find improved methods for teaching NVG performance was indicated. The study recognized that the use of computer-based, multimedia technology would considerably enhance computer-based interactive instruction. It was also recognized that the use of multimedia technology was a relatively new approach in aviation training and that not much was known about how to establish quality standards for use of multimedia in computer-based instruction.

## D. SUMMARY OF APPROACH

The nature of this thesis is to research and compile a comprehensive and current multimedia framework that is tailored to computer-based training. While the focus of this review is centered on aviation training, it is believed that such a methodology may have much wider applications in the Navy. Commercial standards and benchmarking techniques, obtained from printed literature and information available through the Internet, will be used in constructing this framework.

## E. IMPORTANCE OF STUDY

The need for intensive training to ensure that personnel have the necessary skills to use ever more complex and costly equipment has increased while the amount of dollars available to fund the required level of training has fallen. Fleet aviation components within the Department of the Navy have been forced to operate with fewer training resources while still trying to achieve prescribed readiness levels.

More attention is being focused on alternative methods using advanced technology to maintain readiness through training. Increasingly both the Department of the Navy and the Department of Defense have been looking to computers and computer-based instruction to provide realistic yet cost-effective training. New technologies such as virtual reality

provide opportunities for realism and cost effective simulation unmatched in previous systems.

While these more advanced training methods may provide more realism, they also cost money. It is important that multimedia developers and procurers have a means to ensure that funds are spent properly on the correct multimedia systems for their needs.

## F. SCOPE AND LIMITATIONS OF STUDY

The scope of the study will be limited to the following:

- IBM compatible desktop computer systems
- Windows 3.11, Windows 95 and Windows NT as the operating software
- Peripheral components compatible with Windows based PC computer systems
- Windows 3.11, Windows 95 and Windows NT compatible software

# II. LITERATURE REVIEW

Since computers were first introduced in 1945,they have evolved from sophisticated adding machines to a devices that begin to reflect the mental and sensory abilities and demands of its makers (Blattner et al, 1992).

The increase in computing power, coupled with the decline in the cost of PC hardware have driven the increase in the number of multimedia platforms sold in the U.S.(CEMA, 1995). From 1993 to 1995, 9.63 million multimedia PCs were sold in the U.S. (Lanpro, 1997).

Much of the information on multimedia was obtained on the Internet using the World Wide Web and search engines such as Yahoo and AltaVista. Additional information was obtained through LEXUS/NEXUS, IEEE On-line Publications and periodicals such as Windows Sources and PC World.

## A. HISTORY OF MULTIMEDIA

In 1968, Douglas Engelbart introduced the NLS (oN Line System) with its interactive multiperson editing, branching to different files, text search facilities and outline processing (Buford, 1994). The NLS was the first knowledge machine and paved the way for the interactive personal computer.

In 1983, Dave Backer demonstrated the "electronic book" (Buford, 1994). A user reads the book through a touchscreen. Backer's prototype workstation integrated sound, data, images, video presentation and coordinated access to synchronized media. Also, in the 1980's, the emergence of the video disk format made the presentation of multiple information forms technically feasible (Buford,1994).

The direct predecessor of multimedia was interactive video (Oblinger, 1992). Interactive video is a video message, controlled through a computer program, that has been designed to allow an individual to interact with it (Oblinger, 1992). Interactive video provided a means with which users could access and manipulate still images and video in ways that could enhance learning. An example of interactive video is the visual database in which users can access stored images, in still frame or motion, from a computer database. Such images would be available for immediate presentation.

In the 1990s the increase in: graphics, audio, video and processing power, the decrease in costs and the proliferation of multimedia titles have transformed the desktop PC into a viable multimedia platform. The number of <u>multimedia</u> desktops sold in the U.S. rose from 450,000 in

1993 to 2.3 million in 1996 (Lanpro, 1997).

## B. DEFINITION OF MULTIMEDIA

### 1. What are Multimedia?

Multimedia are the simultaneous use of different media to communicate effectively ideas or knowledge using a computer (Hodges and Sasnett, 1993; Schneidermann, 1989; Blattner et al, 1991). These media include text, audio, graphics, video, still images and animation put together in a systematic way to educate or inform an observer or user.

### 2. Why use Multimedia?

Multimedia can be combined with computer-assisted instruction to make learning highly individualized and interactive (Oblinger, 1992). Interactivity increases the learner's engagement with the learning situation (ED, 1991). The increase in hardware performance and availability of software applications has made realistic, seamless interactivity possible with graphically intensive simulations.

## C. DEFINITION OF COMPUTER-BASED TRAINING

### 1. What is Computer-Based Training?

Computer-based training is an interactive learning experience between a learner and computer in which the computer provides the majority of the stimulus (including

interactive video and other multimedia programs and hardware when they are computer driven), the learner must respond, and the computer analyzes the response and provides feedback to the learner (Gery, 1987).

## D. MULTIMEDIA FRAMEWORK

In order to assist a developer or purchaser in evaluating a multi-media system, it will be helpful to enumerate the hardware and software categories that comprise a multi-media system. This process will result in the formulation of a "multi-media taxonomy." In addition, performance benchmarks will be included to provide a means to assess the capabilities of hardware and software systems in the multi-media taxonomy for those who wish to evaluate multi-media systems. The final product will provide a means for multi-media system developers to evaluate existing multi-media component technologies and hopefully will serve as a useful template for assessing new technological advances.

## E. BENCHMARKING

### 1. Benchmarking categories

There are two levels and two types of benchmarks. The two levels are: component and system. Component benchmarks test only a specific part or parts of the computer. System benchmarks test the overall performance of a computer.

The two types of benchmarks are: application and synthetic. Application benchmarks measure performance by using real world applications the way a user might. Synthetic benchmarks use software programs created specifically to test performance. Table 2-1, is a matrix of some commonly used benchhmarks (Intel, 1996).

| | Component Benchmark | System Benchmark |
|---|---|---|
| Application Benchmark | WinBench<br>SPECint95/SPECfp95 | Winstone<br>SYSmark/NT<br>Doom |
| Synthetic Benchmark | CPUmark32<br>ctcm | Norton SI 32<br>3D Bench |

Table 2-1 Matrix of Commonly Used Benchmarks

## 2. Application benchmarks

### a. *System benchmarks*

(1) Winstone® 96. The Winstone/WinBench benchmark suite was created by the Ziff-Davis Benchmark Operation (ZDBOp), a research and development division of Ziff-Davis Publishing. Winstone and WinBench are the PC industry's leading application-based benchmark test suite (Van Name, Catchings, 1996) and are designed to test different aspects of computer performance. Winstone 96 produces a measure of the PC's overall performance by running actual Windows applications. There are thirteen applications

divided into four categories: spreadsheet, word processing, database and business graphics/desktop publishing. The test unit runs scripted tasks containing the applications and once completed, Winstone 96 produces a score. That score is measured against a reference machine—a Dell PC with a 25-MHz 486SX CPU and 8MB of RAM. The reference machine score is set by definition to 10.0 The higher the score of the test machine, the better the performance. A test machine with a score of 30.0 would be three times as fast as the reference machine.

(2) Wintone® 97. Winstone® 97/Winbench® 97 are the latest versions of the test suites developed by ZDBOp (Van Name et al, 1996) but differs from the previous versions in certain aspects. Both Winstone/WinBench 97 use tests that are entirely 32-bit, therefore they can run only on Windows 95 and Windows NT.

Winstone 97 uses six high-end applications in three categories: application development, CAD and three-dimensional applications and image editing. An overall score is and compared to a base machine, with a bigger score signifying a better result. For business tests, the base machine is a Gateway 2000. 486-66 CPU with 16MB of RAM. For high-end applications a Dell XPS P100c with 32 MB of RAM.

(3) SYSmark/NT. Developed by BAPCo, SYSmark/NT is a system performance measurement tool for computers running under the Windows NT operating system. It uses popular word processing, spreadsheet, project management, CAD and presentation graphics applications to provide the benchmarking workloads.

(4) Doom. The Doom benchmark is an example of the growing trend in using popular games, such as Doom and Quake, as system benchmarks. Games, such as Doom, make good multimedia performance indicators because they make heavy demands of processor, graphics, sound and input/output devices. The Doom benchmark uses the game of Doom to provide a relative measure of how fast the game itself runs on a system. These are informal methods that have not been completely documented.

**b. *Component benchmarks***

(1) WinBench® 96. WinBench 96 tests the performance of a PC's processor/RAM, CD-ROM and full motion video subsystems. WinBench 96 uses 13 different tests to conduct 115 different operations to produce the Graphics WinMark and Disk WinMark score. This score is also compared to a reference machine. As with Winstone, the higher the score, the better the performance.

(2) WinBench® 97. WinBench 97 provides detailed information about the performance of a PC's major subsystems: graphics, disk, full-motion video, CD-ROM and processor/RAM. The resulting Graphics and Disk WinMark scores are then compared to a the scores of a reference machine. Both Winstone and WinBench 97 are made by ZDBOp.

(3) SPECint95/SPECfp95. Developed by the Standard Performance Evaluation Corporation (SPEC), SPECint95 and SPECfp95 measure cpu performance. SPECint95 measures performance based on integer computations, while SPECfp95 measures performance based on floating-point computations.

**3. Synthetic benchmarks**

**a. *System benchmarks***

(1) Norton SI 32. Developed by Symantec, Norton SI 32 is a 32-bit benchmark that provides information on system performance. It is part of the Norton Systems Information Utility.

(2) 3D-Bench. 3D-Bench is a benchmarking program that measures the graphics speed of a computer. The performance measurement is determined by the CPU, CPU clock speed, video card performance, BIOS, video bus clock speed, motherboard chipset, caches and jumper settings on the motherboard.

### b. *Component benchmarks*

(1) CPUmark32. CPUmark32 is a 32-bit processor benchmark, developed by ZDBOp, designed to measure performance for 32-bit applications.

(2) ctcm. Ctcm is a motherboard benchmarking utility developed by the German ct-Magazine. It checks the speed of L1 cache,L2 cache, main memory and data transfer speed to and from the graphics card. Ctcm runs only in DOS.

## 4. Rating scales

### a. *P-Rating*

The P-rating system, run by MDR labs, is a processor performance rating. It is obtained by taking a particular processor, installing it in a computer with a standardized configuration and then running the Winstone 96 benchmark. The standard hardware configuration consists of a Tyan motherboard with a Triton chip set and 512-Kbyte synchronous burst cache, a Quantum Fireball 1.08-Gbyte IDE hard drive, a Matrox Millenium PCI video card and a Windows 95 version 4.0 driver. The final score is obtained by averaging the results of three runs of the processor. The scores can then be compared to scores obtained using Pentium processors of various speeds. The score for the vendor processor is compared to the scores obtained on

the Pentium processors and it is assigned according to a score that is greater than or equal to the scores listed for the Pentiums. Currently the P-Rating system is used on Pentium-compatible processors such as those manufactured by NextGen, Cyrix and AMD. Table 2-2 , displays a sample of adjusted scores (Data Depot,1996).

| Pentium Frequency | Score |
|---|---|
| 75MHz | 45.4 |
| 90MHz | 52.1 |
| 100MHz | 55.0 |
| 120MHz | 58.4 |

Table 2-2 Sample of Adjusted Scores For P-Rating System

If, for example, a vendor processor achieved a score of it would be assigned a P-Rating of P100 (Data Depot, 1996).

**b. *iCOMP® Index 2.0***

The iCOMP® Index 2.0 is a processor benchmarking scale developed by Intel. It is intended to reflect native Intel microprocessor performance for the application mix that a typical end user will use today and for the next few years (Intel, 199?). iCOMP uses four 32-bit processor benchmarks and a proprietary

multimedia benchmark to give a weighted performance rating in five categories: traditional business applications, high-end applications, general purpose integer, general purpose floating point and general multimedia, communications and visualization. The rating is compared to a baseline system consisting of: a 120 MHz Pentium processor, 16KB of primary cache, 512KB of secondary cache, 32 MB of EDO RAM, a Matrox Millenium PCI video card and a Creative Labs Sound Blaster 16 audio card. The baseline machine was given an index rating of 100. An example of the rating comparisons is given in Table 2-3, (Intel, 1996).

| Processors | iCOMP® Index 2.0 |
|---|---|
| Pentium® Pro Processor 200MHz | 220 |
| Pentium Pro Processor 180MHz | 197 |
| Pentium Pro Processor 150MHz | 168 |
| Pentium Processor 200MHz | 142 |
| Pentium Processor 166MHz | 127 |
| Pentium Processor 150MHz | 114 |
| Pentium Processor 133MHz | 111 |

Table 2-3 Sample of iCOMP Index Ratings

### 5. MPC Test Suite

The MPC Test Suite is a benchmarking application developed jointly by the MPC Working Group of the Software Publishers Association and the National Software Testing Laboratories. The test suite is designed to determine if hardware is compliant with the MPC Level 3 standard.

## F. COMPONENT CHARACTERISTICS CONSIDERATIONS

The following is a list of hardware and software with a discussion of key characteristics. These characteristics are compiled from multiple sources such as: Multimedia PC Level 3 Specifications (Software Publishers Association, 1996), Multimedia Extensions to the DoD Minimum Desktop Configurations (DISA, 1995), PC Magazine Online, Tom's Hardware Guide, Windows Sources Online and the websites of Intel and IBM.

This section describes each component, in terms of its key characteristics and performance range. Section G provides recommended options based on 97 technology. Definitions of terms can be found in Appendix B.

### 1. Motherboard

The performance of a motherboard is dependent upon the capabilities of the components that it houses and its

architecture. Brand name motherboards such as, Intel and Tyan, are recommended. Some important features that should be considered:

- Supports Flash BIOS
- An adjustable CPU supply voltage
- Number of SIMM banks available to expand memory
- Supports Pentium compatible CPUs
- Supports Universal Serial Bus

**a. Chipset**

The chipset should be able to support:

- SDRAM
- ATA-33 extension
- Supports a 75MHz or greater bus speed

**b. Bus**

The bus architecture should be at least 32-bit. Currently both the VLB and PCI are 32-bit architectures. With the Pentium, PCI is faster than VLB and it incorporates plug and play more readily than does VLB. Bus clock speeds also determine performance with faster clock speeds being better. Most motherboards today support bus speeds between 66MHz and 83MHz.

### c. RAM

The latest advance in RAM technology is Synchronous Dynamic RAM (SDRAM). It is also the only RAM type that is capable of handling up to 100MHz bus speeds. The amount of RAM usually installed, as of 1997, runs anywhere between 16MB and 128MB.

### d. Cache

Cache is divided into two types: Level 1 (L1) and Level 2 (L2). L1 cache resides on the processor and its speed is dependent upon the processor clock speed. Most processors come with 256KB up to 512KB of L1 cache.

L2 cache resides on the motherboard and its speed is dependent upon the motherboard's bus speed. Motherboards usually have from 256K to 512K of L2 cache installed.

### e. Expansion slots

Modern motherboards generally have at least seven expansion slots. Slots tend to be either ISA,VLB or PCI. ISA is an older architecture than PCI or VLB so it is slower and less adaptable. Boards that have a mix of slot types will run more slowly than if they have just one type. The type of slot needed depends on what architecture an expansion card has.

Another thing to keep in mind is the emergence of the Universal Serial Bus (USB) and high speed serial SCSI. The USB is emerging as the latest standard for connecting equipment such as keyboards, monitors and other input devices but is probably too slow for good hard disk performance (Fisco, 1996).

The two major types of drive controllers supported by motherboards are SCSI and IDE. High speed serial SCSI, though more expensive than enhanced IDE, allows transfer rates of up to 400 MB/sec; compared to the 16.7 MB/sec that enhanced IDE is capable of delivering (Fisco, 1996).

**f. CPU**

The basic measure of a cpu's performance is its clockspeed. Clockspeed can only be used as a comparison on chips that have the same architecture. For example, an Intel 486DX-100MHz processor has a higher clockspeed than an Intel Pentium 66MHz processor. The 486 is slower than the Pentium because it has an older architecture (32-bit vs. 64-bit) and because of improvements in chip fabrication. The CPU should have at least 64-bit architecture regardless of the manufacturer. It should also be able to pass the MPC test suite which uses 75MHz and 100MHz Pentiums for its tests. Pentium and Pentium compatible CPUs have clockspeeds ranging from 60MHz (for the older chips) to 200MHz.

## 2. Monitor

Of the two major types of CRTs, shadow mask tubes and aperture-grille tubes, The aperture-grille tube design generally produces a brighter, flatter and crisper display (Bsales, 1996).

### a. Display size

The monitor size should be at least 17 inches measured diagonally. Computer CRTs do not produce a picture edge-to-edge so any monitor size will produce a smaller live area (Bsales, 1996). The 17 inch class size, or above, is needed in order to provide a large enough viewing area to adequately display at the resolutions currently recommended for multimedia displays. Monitors generally come in 14,15, 17,20 and 21 inch sizes.

### b. Resolution

The resolution of monitor is the size of the screen image and is measured in picture elements or pixels for example the higher the resolution, the more pixels that are fit into the display. Higher resolution allows more windows or images to be displayed on the screen. Resolutions range from 640-by-480 up to 1600-by-1200 pixels.

**c. Refresh rate**

The refresh rate, or the frequency a screen is redrawn each second, that a monitor can support will generally decrease as resolution increases.

The minimum recommended refresh rate is set by the Video Electronics Standards Association (VESA) and should be at least 70Hz (Bsales, 1996).

**d. Dot pitch**

The dot pitch of the monitor is the distance between two dots of the same color. The smaller the dot pitch, the sharper the screen image. Most monitors have dot pitches between .30 and .26 mm.

**3. Graphics accelerator**

A graphics accelerator will increase the overall performance of a system (Mace, 1996) and will have a direct effect on the quality of the screen image of a monitor with its ability to support high refresh rates and higher color depths. Graphics accelerators will have 64-bit up to 128-bit bus widths and from 2MB to 8MB of RAM.

**a. Video bus width**

The video bus width of a controller determines how many bits of data can be accepted per clock cycle. Most controllers today can accept 64 bits per cycle (Mace, 1996).

Most boards have ISA, VL or PCI buses with PCI being the best performer.

**b. 3D acceleration**

A card should have a 3D graphics engine with a special purpose driver written for the graphics accelerator. A card with 3D acceleration capability greatly reduces the workload of the CPU by doing most 3D image rendering.

3D images include the z-axis and require the graphics processor to compute features such as removal of hidden lines and shading to produce realistic 3D images. These tasks induce a heavy load on the processor.

**c. VRAM/WRAM**

Video memory affects multiple aspects of the video card performance: the number of colors supported at certain a certain resolution, how efficiently the bus width is used and the refresh rate capability. The more memory on board, the better the performance. Most 3D graphics cards will have between 2MB and 8MB of RAM onboard.

**d. Refresh rate**

The refresh rate of the video card limits the refresh rate that the monitor will be able to use. The higher the refresh rate supported by the card, the higher the refresh rate (up to the design limit) the monitor has. Video

card refresh rates range from 640-by-480 up to 1600-by-1200 pixels.

**4. Motion video playback board**

Because playback of motion video puts a heavy load on the graphics processor, a separate media processor for video playback is recommended (Mace, 1996). Video boards are available that will fit in an expansion slot or directly on a graphics board. Capture board resolutions range from 160x120 to 640x480 with capture frame rates ranging from 24 to 30 frames per second.

**5. Sound boards**

Sound boards should allow for realistic sound reproduction from multimedia titles (Aguirre, 1996). The sound card should come equipped with a wavetable synthesizer and a digital signal processor (DSP). Sound cards usually have 8-bit or 16-bit sampling capability and playback rates from 5kHz to 44.1kHz. They will also have from 1MB to 28MB (upgradeable) of RAM.

**a. Sample rate**

The sampling rate of the card determines the sound quality it produces. Higher sample rates produce better sound quality but require more performance from the sound cards processor and memory. PC sound cards will sample at eight or 16 bits, with 16-bits preferred.

**b. Digital Signal Processing (DSP)**

New digital signal processors can integrate voice recognition and text-to-speech features (Aguirre, 1996).

**c. Wavetable synthesizer**

Wavetable synthesis is considered superior to FM synthesis (Dillon and Leonard, 1995). It has digitally stored samples of instruments and sound stored in its memory. More memory means more and higher quality samples. Sound cards will have from 1MB to 2MB of ROM.

**6. Speakers**

External speakers enhance the quality of sound produced. Most sound cards don't generate enough power, less than 4 watts, themselves to produce quality sound (Aquirre, 1996) therefore the speakers should have their own power source. Power output varies widely depending on the quality of the speakers. The speakers should be capable of at least 30 watts and a frequency response from 20Hz to 20kHz. External PC speakers should also be shielded to prevent EM, which interferes with the monitor.

**7. Storage devices**

Hard disks and CD-ROMs are the two main media used for data storage. Hard drives have better performance than both CD-ROMS and DVD-ROMS and can store more data than CD-ROMs can. Hard drives that approach the storage capacity of

early DVD-ROMs are far more expensive. CD and DVD-ROM drives are useful for holding databases, graphic/video files and other programs that would normally take up enormous amounts of space on the hard drive. Now, CD and DVD-ROMs can be written to, but the price of read/write CD drives are considerably more expensive than read only.

**a. Hard drives**

Hard drive performance is measured by its capacity, transfer rate, access time and seek time. Most hard drives today have storage capacities ranging from 1.0GB to 9.0GB. Transfer rates, access time and seek time are affected by the rotational speed of the hard drive and the cache. Rotational speeds normally range from 3600 to 7200 rpm and cache ranges from 256K to 1024K.

**b. CD-ROM**

Although CD-ROM will eventually be supplanted by DVD-ROM, the huge installed base of CD-ROM drives coupled with the slow development of DVD means that CD-ROM will be available for years to come (Quain, 1996).

The average throughput of CD-ROM drives has increased from 150KB/sec (1X), when CD-ROM drives initially became available, to 1.8MB/sec (12X). It should be noted that most multimedia titles today are written for 2X or 4X drives so there is no noticeable performance difference if

faster drives are used until software is written to take advantage of the higher throughput. The performance of CD-ROMs is measured by transfer rate and access time. Capacity for CDs is currently about 650MB.

**c. DVD**

DVD-ROM disks have much greater capacity than CD-ROM disks. Currently they are a capable of holding 4GB now and eventually they will hold up to 17 GB. Using MPEG2 encoding technology, the DVD-ROM will provide full motion video and interactivity. The companies producing DVD-ROMs have gone to great lengths to ensure backwards compatibility (Hughes, 1996). Because of the increased pit density, DVD-ROMs will have higher transfer rates than CD-ROMs.

**8. Printers**

Of the three types of printers: dot matrix, ink-jet and laser. Laser printers are the most expensive but produce the highest quality printouts.

The list of relevant features of printers are included below.

**a. Page Description Language (PDL)**

PDL is the format for which image information is transmitted from the PC to the printer. The two major PDL standards are: Hewlett-Packard's PCL and Adobe's PostScript

Level 2. PCL supports 300 dpi, PCL 5e and PostScript support at least 600 dpi.

**b. Resolution**

The higher the resolution, measured in dots per inch, the better the output from the printer. Higher resolution makes a bigger difference in picture quality than it does with text quality. Resolutions range from 300dpi to 1200dpi.

**c. Memory**

The amount of memory in the printer affects determines the amount of space it has to manipulate a document (Computer Shopper, 1995). More memory allows for quicker handling of documents with multiple fonts and graphics. On-board memory for laser printers will usually be from 1MB to 6MB.

**d. Pages per minute (PPM)**

The engine speed of the printer determines the output in pages per minute of the printer. Most printers use a Canon engine and will therefore be able to print up to 12ppm, depending on the complexity of the document and if different colors are used.

**9. Scanners**

The scanner should be a flatbed, full page (8.5x11") and should have a multi-feeder sheet. The performance of a

scanner is measured in its resolution and the color depth it supports. The current "rule of thumb" is that you need twice as much input resolution, dpi, for the corresponding output, lpi. For example if you wanted an output resolution of 300dpi, you would need an input resolution of 600dpi. (Fenton, 1995).

Most scanners will deliver between 300 to 600dpi and interpolated resolutions between 1200 to 9600dpi.

### 10. Software

Regardless of how good the hardware is, the quality of the final product depends as much on the software as it does the hardware. Great care must be taken in choosing software. Is it optimized to run on a 32-bit operating system? What are it's capabilities? What kinds of tools does it come with? What is the reputation of the vendor in providing technical support? These questions should be answered before a particular application is acquired.

#### a. Operating system

Although many systems still use Windows 3.1, Windows 95 considered the current standard for use in multimedia applications. 32-bit operating systems run faster than 16-bit operating systems and will allows programs that have been optimized for it faster than non-optimized programs. Windows 95 is not a true 32-bit operating system

because it has features in it to make it compatible with older 16-bit applications. Windows NT is a true 32-bit operating system and is more robust than Windows 95, but as yet it does not have the product support base (i.e. drivers, applications) that Windows 95 has.

**b. Authorware**

Authorware or authoring tools are needed by developers to produce various multimedia applications. While there are different authoring tools available, most have certain categories of tools such as: digitizing mixed media types, interfacing with different media peripherals, production tools, etc. (Dillon et al, 1995). Authorware evaluation methods were previously developed by Foster and Price (1996) and will not be discussed in detail here (see Appendix B for a summary of their evaluation criteria).

**c. Application program interface**

Application program interfaces are necessary for an OS to access or interface with other devices such as: graphics hardware, 3D accelerators, joystics, etc.. The APIs need to be written properly in order to take advantage of the added performance of the devices.

## G. RECOMMENDED PERFORMANCE STANDARDS

The following is a list of the most current recommended performance standards for multimedia components.

The recommendations were obtained from the same sources as the Component Characteristics Considerations section. The component list and associated performance recommendations are included in a checklist contained in Appendix A.

### 1. Motherboard

The motherboard should have a 75MHz bus speed or greater. There are buses with 83MHz speeds with 100MHz bus speeds in development.

#### b. Bus

The bus architecture should be at least 32-bit PCI.

#### c. RAM

For multimedia development systems, at least 32MB of SDRAM expandable to 128MB with a memory speed of 60 nanoseconds is recommended.

#### d. L2 Cache

At least 512K of Pipelined Burst Static RAM (PB SRAM) with a memory speed of at least 8 nanoseconds is recommended, although there are chipsets now that can support up to 2048K L2 cache.

#### e. Expansion slots

The motherboard should have at least 7 expansion slots. They tend to be a mix of PCI, ISA and VLB.

**f. CPU**

Although the MPC Level 3 specification is based clock speeds of 75 or 100MHz, today's systems usually come with processors that are 166MHz or faster.

The L1 cache should have at least 256K of write-back cache.

## 2. Monitor

The monitor display should be non-interlaced with an aperture-grille tube design.

**a. Display size**

The monitor size should be at least 17 inches measured diagonally.

**b. Resolution**

The monitor should be able to handle a resolution of at least 1024-by-768 although 17" monitors can usually handle 160-by-1200.

**c. Refresh rate**

The Video Electronics Standards Association (VESA) recommends a refresh rate of at least 75MHz (Bsales, 1996), although that may soon increase to 80MHz, since screen flicker is visible at resolutions below 70MHz.

**d. Dot pitch**

The mask pitch of the monitor should be .28mm or less.

### 3. Graphics accelerator

The graphics accelerator, in addition to being able to support resolutions of at least 1024-by-768, needs to have 3D hardware acceleration, MPEG-1, playback capability and motion video acceleration and scaling built into the controller card. The fastest cards available today have at least a 64-bit data path and PCI architecture.

#### a. Video bus width

The video bus width should be at least 64-bits. There are video cards with 128-bit bus widths available. However, to make use of the entire bus width, a 64-bit card requires at least 2MB of onboard memory and the 128-bit card at least 4MB of onboard memory.

#### b. 3D acceleration

The card should have a 3D graphics engine with a special purpose driver written for the particular card. A card with 3D acceleration capability greatly reduces the workload of the CPU by doing most of rendering.

#### c. VRAM/WRAM

In order to support high or true color at resolutions of 1024-by-768, at least 4MB of VRAM/WRAM are needed. Since future graphics applications will become more intensive, the card's memory also should be expandable up to 6MB or 8MB.

**d. Refresh rate**

As with the monitor, the graphics card should support a refresh rate of at least 75MHz (80MHz if possible) at the 1024-by-768 resolution.

**4. Motion video playback board**

The board should be able to handle video capture of NTSC video at 30 frames per second, 24-bit color, on-the-fly compression to Motion JPEG and MPEG1 encoding/decoding. When DVD arrives, it will be necessary for boards to have MPEG2 encoding and decoding capability.

**5. Sound boards**

**a. Sample rate**

In order to deliver CD-quality stereo sound, the card must be capable of 16-bit 44-kHz stereo sampling.

**b. Wavetable synthesizer**

The wavetable synthesizer should be able to deliver 4MB of high-quality samples. To do this, it will need at least 2MB of ROM.

**6. Speakers**

Multimedia speakers should be able to handle frequencies ranging from 150Hz to 20kHz and be able to deliver at least 30 watts of power.

### 7. Storage devices

#### a. Hard drives

The best desktop drives spin at 5,400 rpm and there are high performance drives that spin at 7,200 rpm (Bryan, 1996). The amount of cache recommended for a hard drive depends upon the storage capacity. For a 2.1GB drive, there should be at least 512KB.

(1) Capacity. The minimum capacity for a hard drive should be 2.1GB.

(2) Transfer rate. The interface transfer rate should be at least 10MB/sec.

(3) Access time. The average access time be 10 milliseconds or less.

(4) Seek time. The average seek time should be less than or equal to 12 milliseconds.

#### b. CD-ROM

(1) Capacity. The capacity of CD-ROMs is 650MB.

(2) Transfer rate. The transfer rate should be at least 1.2MB/sec (8X).

(3) Access time. The average service access time should be less than or equal to 250ms.

c. DVD

(1) Transfer rate. The nominal transfer rate of the DVD is 10.08MB/sec which is approximately 8 times faster than an 8X CD-ROM drive (Hughes, 1996).

**8. Printers**

**a. Page Description Language (PDL)**

The make of the printer determines which PDL is used.

**b. Resolution**

The resolution standard is 600 dpi. 1,200 dpi will eventually become the standard but it requires more memory and it slows down throughput.

**c. Memory**

Using PCL, the standard memory is 2MB of RAM to print at 600 dpi. Using PostScript, 6MB of RAM are required to print at 600 dpi.

**d. Pages per minute (PPM)**

Most laser printers today are rated at 12ppm.

**9. Scanners**

The scanner should be a flatbed, full page (8.5x11") and should have a multi-feeder sheet.

**a. DPI**

True resolution should be a minimum of 600 dpi, with interpolation up to 4800 by 4800 dpi.

**b. Color depth**

The scanner should be capable of at least 24-bit color.

**10. Software**

The software should be optimized for 32-bit operating systems.

**a. Operating system**

The operating system should be 32-bit. That means either Windows 95 or Windows NT.

**b. Authorware**

A list of authorware features was compiled for the thesis "Instructional Design of Computer-Based Training" (Foster and Price, 1996). It is included in Appendix B.

**c. Application program interface**

Microsoft has developed a family of APIs called DirectX. These include APIs for: 2D and 3D graphics accelerators, sound boards and hardware, input devices and video.

# III. METHODOLOGY

## A. INSTRUMENT

The assessment tool is a checklist with three columns labeled:

- Component
- Recommended Specifications
- Actual Specifications.

The component column is comprised of two major categories: hardware and software.

The hardware category is divided into nine sub-categories:

- Motherboard
- Monitor
- Graphics Accelerator
- Video Board
- Sound Board
- Speakers
- Storage
- Printer
- Scanner

The software category is divided into two sub-categories:

- Operating System
- APIs

Each of the sub-categories list individual components or sub-components.

The recommended column and contain either performance recommendations for those components or capability recommendations.

The actual column can be used to write down what the capability is of the system that is being assessed or whether the system meets or exceeds the performance recommendations.

Information on the components and performance recommendations was obtained from sources identified in the literature review. An example of the assessment tool is located in Appendix A.

## B. EVALUATION PROCEDURES

### 1. Obtain component specifications

The component specifications for each of the sub-categories was obtained through three means:

- Specifications included with the component
- The homepage of the manufacturer (if available) located on the World Wide Web
- Contacting the manufacturer

Once the information on all the components had been received then the evaluation could begin.

**2. Component evaluation**

The system was evaluated for each of the components in terms of meeting or exceeding the criteria listed in the corresponding cell of the recommended column. For example in the component sub-category, motherboard, it asks if the motherboard is SDRAM capable. In the corresponding row of the recommended column it says "Y" (yes). The response would either be "Y" (yes) or "N" (no) in the actual column. Another example in the same sub-category, for bus speed, the corresponding row in the recommended column has "≥75MHz". The actual bus speed of the system being evaluated would be annotated in the corresponding row in the actual column.

The evaluation was done for each component on the checklist with the response annotated in the actual column.

**3. Final evaluation**

The final evaluation was based on matching the recommended values and whether or not the users particular system met or exceeded each of the criteria.

Because of the advance in performance, evaluators are encouraged to modify and update the checklist taking into consideration the most current technology, performance

baselines for both hardware and software or particular needs of evaluators.

# IV. RESULTS

## A. STATE OF THE ART

### 1. Motherboard

#### a. Chipset

While there are many chipset manufacturers, the three major chipset makers are Intel, VIA and SiS. Intel's 430HX,430VX and 430TX, VIA's Apollo-VP and SiS's 5571 chipsets are the most current offerings from these firms.

Modern chipsets should support a 75MHz bus speed, the ATA-33 extension, USB, AGP and SDRAM.

#### b. RAM

SDRAM is considered to be the state-of-the art RAM now and the RAM for the near term. It has the best performance of any type of RAM and is the only type that supports the faster bus speeds.

For cache (L1 and L2), synchronous burst SRAM is currently the best performer.

#### c. CPUs

There are three major PC chip makers. Intel, Cyrix and AMD. Intel's most current and highest performance chips are the Pentium MMX and Pentium Pro.

The MMX is basically a Pentium chip with an added set of instructions tailored to multimedia tasks thus it is somewhat more expensive than non MMX pentiums. It does offer a performance advantage of previous generation pentiums but in order to take full advantage of its capabilities, applications need to be optimized for the MMX.

The Pentium Pro incorporates advances in architecture that are designed to deliver better performance with 32-bit applications and unless such applications are used, the performance gain is not very high.

Cyrix's most current processor is the 6x86 or M1. The 6x86 has a cache access speed twice as fast as a Pentium but has a slower floating point unit.

AMD's pentium-compatible processor is the K5. It offers similar performance to the Pentium. Its floating point unit is slower than the Pentium's but faster than the 6x86's.

**2. Monitor**

The two main display types are the CRT and the LCD. The CRT is still the dominant type right now because it is still much cheaper than an LCD screen of the same size and picture quality. LCD screens are used primarily for notebooks.

### 3. Graphics Accelerator

3-D accelerator boards are now the mainstream graphics boards. Critical performance capabilities should include accelerated texture mapping, rasterizing, Z-buffering and shading.

### 4. Video Board

Video boards offer hardware-based MPEG decoding which is much faster than software-based MPEG decoding. MPEG1 is still the predominant form of encoding but as DVD becomes available, video boards will have to have the ability to decode MPEG2. Most boards can handle 30fps video rates which provide TV quality pictures.

### 5. Sound Board

16-bit soundboards provide CD quality sound. Top of the line cards will also have DSP and wavetable synthesis.

### 6. Speakers

Multimedia speakers should have their own built-in amplifiers with high-end systems also having powered sub-woofers and digital signal processing.

### 7. Storage

Multimedia PCs will have a hard drive and a CD-ROM drive as standard components. Although EIDE hard drives are the standard for PCs, they don't perform as well as high-speed SCSI drives and they put a greater load on the CPU. But they are cheaper are supported by the motherboard

whereas SCSI drives require a seperate controller card. Most high performance hard drives will have at least 2GB or more storage capacity, rotational speeds of at least 5400 rpm and will have at least 512K built-in cache.

CD-ROMs now have tranfer rates of up to 1800Kb/sec and access times ranging from 140ms to 180ms. While DVD-ROMs will offer better performance and much more storage than CD-ROMs, they are just now coming out. That means that CD-ROMs are still the standard due to their huge installed base and the number of titles available on CDs.

#### 8. Printers

Most laser printers today have at least a 12ppm capability, 600dpi resolution and 2MB of memory.

#### 9. Scanners

The latest desktop scanners have 32-bit color resolution, true optical resolution of up to 1200dpi and interpolation up to 9600dpi.

#### 10. Software

When considering software, the standard now is that it be coded to take advantage of 32-bit operating systems.

### B. ASSESSMENT TOOL APPLICATION

The assessment tool described in the Methodology Chapter, was applied to a "real-world" multimedia system.

The system that was analyzed was the multimedia PC recently purchased by the School of Aviation Safety Media Lab loacated at the Naval Postgraduate School, Monterey, California.

First, the system information was obtained; using the Packing List provided by the vendor, the Home pages of the sub-component manufacturers and specification sheets provided with the system.

Next, the information was recorded for each of the sub-components and then compared to the recommended performance parameters.

Finally an overall assessment of the system was made and a brief look at the emerging technologies as they apply to this assessment tool will be taken.

## C. SYSTEM EVALUATION

The results of the information search on component specifications for the Media Lab computer are listed below:

1. Motherboard

| | |
|---|---|
| a. Chipset- | Intel 82430HX |
| 1. SDRAM capable- | NO |
| 2. ATA-33 support- | NO |
| 3. Bus speed- | 66MHz |
| 4. L2 cache support- | 512KB |
| 5. USB support- | Y |
| 6. Hi-speed SCSI- | N |
| 7. E-IDE- | Y |
| 8. Multi-processor capable- | Y |

| | |
|---|---|
| b. RAM- | 64MB |
| 1. SDRAM- | N |
| 2. Speed- | 60ns |
| c. CACHE- | 256KB |
| 1. PB SRAM- | N |
| 2. Speed- | 8ns |
| d. Expansion slots | |
| 1. Total No.- | 7 |
| 2. No. PCI- | 4 |
| 3. No. ISA- | 3 |
| e. CPU | |
| 1. Clock speed- | 166MHz |
| 2. 64-bit- | Y |
| 3. L1 cache- | 256WB |

2. <u>Monitor</u>

| | |
|---|---|
| a. Display size- | 21″ |
| b. Resolution support- | 1600x1200 |
| c. Refresh rate- | 80MHz |
| d. Pitch- | .25mm |

3. <u>Graphics Accelerator</u>

| | |
|---|---|
| a. PCI- | Y |
| b. Video Bus width- | 64-bit |
| c. 3D Acceleration- | Y |
| d. 3D driver support- | Y |
| e. VRAM- | 4MB |
| f. Refresh rate- | 75MHz@1024x768 |

4. <u>Video Board</u>

| | |
|---|---|
| a. MPEG1 encode/decode- | Y |
| b. MPEG2 encode/decode- | N |
| c. Color depth- | 24-bit |

d. Video capture rate- 30fps

5. Sound Board

a. Sample rate- 16-bit@ 44kHz

b. DSP- N

c. Wavetable synthesis- N

6. Speakers

a. Range- 70Hz - 20kHz

b. Output- 10 watts

7. Storage

a. Hard drive

1. Capacity- 2.1GB
2. Transfer rate- 16.6MB/sec
3. Access time- ?
4. Seek time- 12ms
5. Rotational speed- 5200rpm
6. Cache- 128KB

b. CD-ROM

1. Capacity- 650MB
2. Transfer rate- 900MB/sec (6X)
3. Access time- 175ms
4. Recordable Drive- Y

c. DVD-ROM- N

8. Printer

a. Laser- Y

b. PDL- PCL

c. Resolution- 600dpi

d. Memory- 2MB

e. PPM- 8

9. Scanner

| | |
|---|---|
| a. Flatbed (8.5″ x 11″)- | Y |
| b. Multi-form feed- | Y |
| c. Resolution- | 400dpi |
| d. Interpolation- | 1600dpi |
| e. Color depth- | 24-bit |

10. Operating System

| | |
|---|---|
| a. 32-bit- | Y |

11. APIs

| | |
|---|---|
| a. DirectX 2.0- | Y |

## D. SUMMARY

In its present configuration, the Multimedia Lab's computer has some components that meet or exceed the performance recommendations and some components that do not meet some of the recommendations.

The components that meet or exceed the recommendations are: CPU, monitor, graphics accelerator and video board.

The components that do not meet some or all of the recommendations include:

- The motherboard chipset does not support SDRAM, ATA-33, 75MHz or greater bus speed and 512KB or greater cache.

- The sound board does not have DSP capability or have wavetable synthesis.

- The speakers do not have a power output of greater than 30 watts.

- The hard drive does not support cache greater than 256Kb.

- The cd-rom drive has a transfer rate less than 1.2MB.
- There is no DVD-ROM installed on the computer.
- The printer is capable of only 8ppm.
- The scanner only supports 600dpi resolution and 1600 dpi interpolation.

## E. NEAR-TERM STATE OF THE ART

This section includes a look at upcoming advances in hardware technology and performance for the major component sections which do have upgrades coming out soon.

### 1. Motherboard

Motherboards capable of 100MHz bus speeds, RAM capacity of greater than 512MB, cache capacity of 2048KB and support for the AGP standard.

For CPUs all three major chipmakers have new products in development. Intel has the Klamath which has the MMX instruction set, a more powerful floating point unit and a an updated bus. The more powerful floating point unit will mean faster 3D graphics. Cyrix will be coming out with the M2 which is the M1 chip with an MMX compatible instruction set. AMD will have the K6 which also includes MMX compatible instructions.

**2. Monitor**

LCD monitors offer distortion free graphics, lighter weights and eventually the prices of current LCDs will drop enough to make them realistic alternatives the heavier and bulkier CRT monitors which dominate today.

**3. Graphics accelerators**

Faster 3D hardware acceleration, more powerful processing engines and more memory will be the trend for graphics accelerators.

**4. Video boards**

In order to take advantage of DVD, video boards will be available with MPEG2 encoding/decoding capability. Eventually, media processor boards with MPEG2 decompression, AC-3 (Dolby Surround sound) and communications functions will become standard (CRW, 1996). The multimedia board will also

handle the standard multimedia tasks and take the place of sound and video boards.

### 5. Storage

DVD will be the mass storage media of the future. With capacities starting at 4.7GB and increasing to 18GB of data.

Hard drives with rotational speeds of greater than 10000 rpm and increased on-board cache and of course storage capacity will become the mainstream.

### 6. Other trends in Multimedia

The implementation of virtual reality, with 3D visors and input devices (such as gloves) will further enhance the interactivity of computer-based training.

Authorware itself is being developed to use 3D environments as the primary interface between the application and the user.

# V. CONCLUSIONS

## A. SUMMARY

The assessment checklist was developed for the purpose of providing a reasonably comprehensive taxonomy of multimedia hardware and software, along with performance recommendations, in a single document. The resulting taxonomy is intended for use by the target audience of system developers and purchasers to provide a means of evaluating a system's, or component's, current specifications and give them metrics with which they can base new system purchases or component upgrades.

Once the information regarding multimedia components and their performance characteristics was obtained, it was assembled in a checklist format that would allow information from a multimedia system to be written down and compared easily tothe current state of the art recommendations.

The information used to formulate the multimedia assessment checklist was obtained from the Internet, trade publications, DoD multimedia desktop standards and industry multimedia specifications(MPC group).

## B. RECOMMENDATIONS FOR SYSTEM UPGRADE

Alhough a multimedia computer system was purchased by the School of Aviation Safety Media Lab in September 1996, there are a number of components and peripherals that do not meet the recommended specifications because of obsolescence, as outlined in the previous chapter. Therefore the following upgrades are recommended for the lab's computer:

- Motherboard: Currently, no single chipset from the major manufacturers supports all of the performance recommendations. The Intel 84320HX chipset supports only a 66MHz bus speed and does not support SDRAM. The VIA Apollo chipsets don't support multi-processor capability. Since most applications are not yet written to take advantage of multi-processor capability, the Apollo chipset is the better choice for now.
- RAM: Replace the EDO RAM with SDRAM.
- L2 cache: Increase the amount of L2 cache to 512KB PB SRAM.
- CPU: Replace the current Pentium 166MHz with a Pentium MMX or Pentium Pro of equal or greater clock speed.

- Video board: Replace the current video board with one that also decodes MPEG2 such as LSI Logic's Scenario VM102 or other brands as they become available.
- Sound board: Replace the current sound board with a Sound Blaster 32 compatible that has DSP and Wavetable Synthesis and 2MB of ROM.
- Speakers: Replace the current speakers with a system that has speakers capable of greater than 30 watts output, a powered subwoofer and 3D surround capability. Examples of systems include: Labtec SB-8, Altec Lansing ACS500 and Multimedia Labs TC1500.
- Hard drive: Replace the hard drive with a model that has at least 256KB cache and rotational speed of greater than 5400 rpm. A SCSI adapter/controller should also be a consideration because SCSI drives generally outperform IDE drives. Examples of candidate drives include: Seagate's Hawk 2XL, Western Digital's Enterprise and Quantum's Atlas.
- CD-ROM: Replace the CD-ROM with one capable of a transfer rate of at least 1.2MB/sec.
- DVD: Install DVD ROM drive as players become more widely available.

- Printer: Replace printer with a model capable of 12 ppm, and at least 6MB of RAM. Examples of qualifying models include: Lexmarks OPTRA LXN+ and Okidata's OL1200/PS.
- Scanner: Replace the scanner with an HP Scanjet or that is capable of at least 600dpi true resolution and interpolation of at least 4800 by 4800 dpi. Examples of qualifying models include: HP Scanjet 4C, Microtek Scanmaker III and UMAX Powerlock II.

## C. RECOMMENDATIONS FOR USERS OF THE CHECKLIST

The checklist is intended to be a guide for system developers and purchasers. Those who find it useful are encouraged to tailor or improve it to fit their respective needs by including new technologies such as virtual reality or new performance baselines.

Because of the rapidly increasing performance of most hardware and software, the best way to stay abreast of changes is through the Internet or periodicals such as Windows Sources, PC World and PC Magazine that deal with multimedia and multimedia technologies.

## LIST OF REFERENCES


Aguirre, Holly, "The Perfect Sound," PC Magazine: The Perfect Components [Online] Available http://www.pcmag.com/features/perfectpc/comp/sound2.htm, February 1, 1997.

Bsales, Jamie M., "The Perfect Monitor," PC Magazine: The Perfect Components [Online] Available http://www.pcmag.com/features/perfectpc/comp/monitor.htm, February 1, 1997.

Blattner, Meera M., and Roger B. Dannenberg, *Multimedia Interface Design*, ACM Press, New York, 1992.

Bryan, John, "The Perfect Hard Disk," PC Magazine: The Perfect Components [Online] Available http://www.pcmag.com/features/perfectpc/comp/harddisk.htm, February 1, 1997.

Buford, John F., *Multimedia Systems*, ACM Press, New York, 1994.

Computer Shopper, "Powerhouse Printers: Before You Buy," Computer Shopper [Online] Available http://www5.zdnet.com/cshopper/features/9510/feature3/sub1.htm, February 2, 1997.

Consumer Electronics Manufacturers Association, "The Year in Consumer Electronics: Multimedia," [Online] Available http://www.cemacity.org/cemacity/mall/product/comp/files/yearin.htm, January 26, 1997.

Data Depot Inc., "Processor Performance Rating (P-Rating) Specification," Data Depot [Online] Available http://www.datadepo.com/prating.htm, February 2, 1997.

Dillon, Patrick M. and David C. Leonard, *Multimedia Technology From A to Z*, Oryz Press, Pheonix, AZ, 1995.

DISA, "Multimedia Extensions to the DoD Minimum Desktop Configuration," Defense Systems Information Agency [Online] Available http://sc.ist.ucf.edu/~OTT/refs/stds/mmexten.htm, October 25, 1996.

Dyson, Peter, *The PC User's Pocket Dictionary*, Sybex Press, Alameda, CA, 1994.

ED340388, ERIC Digest, Office of Educational Research and Improvement, 1991.

Ertl, Anton, "Doom benchmark results," [Online] Available http://www.complang.tuwien.ac.at/misc/doombench.html, January 28, 1997.

Feibus, M., "Multimedia PCs," *Windows Sources*, v. 4 no. 10. pp. 163-213, October, 1996.

Fenton, Howie, "Shopping For a Scanner or Scans," Electric Pages [Online] Available http://www.electric-pages.com/fenton/buyscan.htm, February 2, 1997.

Fisco, Richard, "The Perfect Motherboard," PC Magazine: The Perfect Components [Online] Available http://www.pcmag.com/features/perfectpc/comp/mother.htm, February 1, 1997.

Foster, Robert. W., and Alfred B. Price, *Instructional Design Of Computer-Based Training*, Master's Thesis, Naval Postgraduate School, Monterey California, December, 1996.

Gery, G., *Making CBT Happen: Prescription for Successful Implentation of Computer-Based Training in Your Organization*, Weingarton Press, Boston, Maryland, 1987.

Gleeson, Marius, "Motherboards," 3 Guys Publishing [Online] Available http://www.os2zone.aus.net/demo/art/marius/mboards.html, January 25, 1997.

Hodes, Matthew E. and Russel M. Sasnett et al, *Multimedia Computing*, Addison-Wesley Publishing Company 1993.

Hughes, Kilroy, Frequently Asked Questions About DVD, Future Media Systems [Online] Available http://www.cd-info.com/CDIC/Technology/DVD/dvd-faq.html, December 10, 1996.

IBM, "Synchronous DRAMS: The DRAM of the Future," IBM [Online] Available http://www.chips.imb.com/products/memory/sdramart/sdramart.html, January 25, 1997.

Intel, "Application and Synthetic Benchmarks," Intel [Online] Available http://channel.intel.com/procs/perf/intro/compo.htm, January 31, 1997.

Intel, "Component vs. System Level Benchmarks," Intel [Online] Available http://channel.intel.com/procs/perf/intro/appsyn.htm, January 31, 1997.

Intel, iCOMP®Index 2.0 White Paper, Intel [Online] Available http://134.134.214.1/procs/perf/icomp/icomp_paper/index.htm, January 30, 1997.

Lanpro, "Multimedia PC Sales", Lanpro [Online] Available http://www.iarts.com/mpc.htm, January 26, 1997.

Mace, Jeff, "The Perfect Graphics Accelerator," PC Magazine: The Perfect Components [Online] Available http://www.pcmag.com/features/perfectpc/comp/graphic.htm, February 1, 1997.

Moe, Jeff, Hard Drives, [Online] Available http://www.verinet.com/pc/hd.shtml, February 14, 1997.

Oblinger, Diana, *Introduction to Multimedia Instruction: A Primer*, University of North Carolina Press, 1992.

Pabst, Thomas, Tom's Hardware Guide [Online] Available http://www.sysdoc.pair.com, February 4, 1997.

Peterson, John and Paul Staricco, SYSmark32 for Windows 95 and Windows NT, BAPCo [Online] Available http://www.bapco.com/sys32.htm, February 8, 1997.

Quain, John R., "The Perfect CD-ROM Drive," PC Magazine: The Perfect Components [Online] Available http://www.pcmag.com/features/perfectpc/comp/cdrom.htm, February 1, 1997.

Schneiderman, Ben and Greg Kearsly, *Hypertext Hand-on*, Addison-Wesley Publishing, 1989.

Scott, Michael, The PC Video Hardware FAQ. [Online] Available usenet: comp.sys.ibm.pc.hardware.video, February 4, 1997.

Software Publishers Association, "Multimedia PC Level 3 Specification," Software Publishers Association [Online] Available http://www.spa.org/mpc/mpc3spec.htm#CPU, January 21, 1997.

SPEC, A SPEC Primer, Standard Performcance Evaluation Corporation [Online] Available http://www.specbench.org/spec/specfaq.html, February 1, 1997.

Starr, Daniel, 3D Acceleration Primer, [Online] Available http://www.dimension3d.com/software/primer.html, February 4, 1997.

Van Name, Mark and Bill Catchings, "PC benchmarks add high-end test suites," PCWEEK [Online] Available http://www.pcweek.com/reviews/1118/18bench.html, January 25, 1997.

## APPENDIX A: SYSTEM CHECKLIST

| COMPONENT | RECOMMENDED SPECIFICATION | ACTUAL SPECIFICATION |
|---|---|---|
| **Motherboard** | | |
| Chipset | | |
| SDRAM capable | Y | |
| ATA-33 support | Y | |
| Bus speed | ≥75MHz | |
| L2 cache support | ≥512K | |
| USB support | Y | |
| Hi-speed SCSI | | |
| E-IDE | | |
| Multi-processor capable | Y (if OS supports) | |
| Flash BIOS | Y | |
| RAM | ≥32MB | |
| SDRAM | Y | |
| Speed | ≤60ns | |
| CACHE | | |
| PB SRAM | Y | |
| L2 | ≥512K | |
| Speed | ≤8ns | |
| Expansion slots | | |
| Total No. | 7 | |
| No. PCI | | |
| No. ISA/VLB | | |
| CPU | | |
| Clock speed | ≥100MHz | |
| 64-bit | Y | |
| L1 cache | ≥256WB | |
| PB SRAM | Y | |
| **Monitor** | | |
| Display size | ≥17″ | |
| Resolution support | ≥1024 X 768 | |
| Refresh rate | ≥75MHz | |
| Pitch | ≤.28mm | |
| | | |
| **Graphics Accelerator** | | |
| PCI | Y | |
| Video bus width | ≥64-bit | |
| 3D Acceleration | Y | |

| | | |
|---|---|---|
| 3D Driver support | Y | |
| VRAM | ≥4MB | |
| Refresh rate | ≥75MHz@1024x768 | |
| | | |
| **Video Board** | | |
| MPEG-1 encode/decode | Y | |
| MPEG-2 encode/decode (DVD) | Y | |
| Color depth | ≥24-bit | |
| Video capture rate | 30fps | |
| | | |
| **Sound board** | | |
| Sample rate | 16-bit@ 44kHz | |
| DSP | Y | |
| Wavetable Synth. | Y | |
| ROM | ≥2MB | |
| | | |
| **Speakers** | | |
| Range | 150Hz - 20kHz | |
| Output | ≥30 watts | |
| | | |
| **Storage** | | |
| Hard drive | | |
| Rotational speed | ≥5400rpm | |
| Cache | ≥512K | |
| Capacity | ≥2.1GB | |
| Transfer rate | ≥10MB/sec | |
| Access time | ≤10ms | |
| Seek time | ≤12ms | |
| CD-ROM | | |
| Capacity | 650MB | |
| Transfer rate | ≥1.2MB/sec (8X) | |
| Access time | ≤250ms | |
| Recordable | | |
| DVD-ROM | | |
| Capacity | ≥4GB | |
| Transfer rate | ≥10.08MB/sec | |
| Recordable | | |
| | | |
| **Printer** | | |
| Laser | Y | |
| PDL | PCL 5e/ Adobe PostScript | |

| | | |
|---|---|---|
| Resolution | ≥600dpi | |
| Memory | | |
| PCL | ≥2MB | |
| Adobe PostScript | ≥6MB | |
| PPM(Black&White) | ≥12ppm | |
| | | |
| **Scanner** | | |
| Flatbed (8.5 x 11") | Y | |
| Multi-form feed | Y | |
| Resolution | ≥600dpi | |
| Interpolation | ≥4800x4800dpi | |
| Color depth | 24-bit | |
| | | |
| **Operating System** | | |
| 32-bit | Y | |
| | | |
| **APIs** | | |
| DirectDraw | Y | |
| Direct3D | Y | |
| DirectInput | Y | |
| DirectSound | Y | |
| DirectVideo | Y | |

# APPENDIX B: AUTHORWARE CHECKLIST

| FUNCTIONAL CAPABILITY | Y | N |
|---|---|---|
| **GENERAL** | | |
| Accepts DLL | | |
| OLE 2.0 C/S | | |
| | | |
| **DEVELOPER INTERFACE** | | |
| Text Bases | | |
| Zoom Views | | |
| Tool Box | | |
| Debugging | | |
| Security Access | | |
| Help Wizard | | |
| | | |
| **PROGRAMMING** | | |
| Scripting Language | | |
| Data Validation | | |
| Object Oriented | | |
| Parameter Based | | |
| Procedural Scripting | | |
| Templates | | |
| | | |
| **USER INTERFACE** | | |
| Alphanumeric | | |
| Check Boxes | | |
| Dialog Boxes | | |
| Drag and Drop | | |
| Palettes | | |
| Pull-down Menus | | |
| Radio Buttons | | |
| | | |
| **NAVIGATION** | | |
| Dynamic Hyper-Links | | |
| Forward/Backward | | |
| Go To Commands | | |
| Jumps To | | |
| | | |
| | | |

# APPENDIX C: DEFINITIONS

## A. Hardware

1. **access time-** the period of time that elapses between a request for information from disk to memory and the information arriving at the requesting device. Normally measured in nanoseconds for memory and milliseconds for hard disks.
2. **AGP-** accelerated graphics port. A dedicated port directly linking graphics to memory.
3. **ATA-33-** an extension, developed by Intel, that allows a 33MB/sec transfer rate from enhanced-IDE hard disk drives.
4. **Bus Speed-** the clock speed of a data pathway.
5. **cache-** A special area of memory that improves performance by storing the contents of frequently accessed memory locations and their addresses.
6. **CD-ROM-** compact-disc read-only memory. A high capacity, optical storage device that uses compact disc technology to store large amounts of information, up to 650MB.

7. **DVD-ROM**- digital versatile/video disc read-only memory.

8. **chipset**- controls various functions of the motherboard such as memory I/O, bus I/O and handle interrupt requests (IRQs) and direct memory accesses (DMAs).

9. **CPU**- central processing unit. The control and computing part of the computer.

10. **DRAM**- dynamic random access memory. A common type of computer memory that uses capacitors and transistors storing electrical charges to represent memory states. The capacitors need to be refreshed every millisecond, during which time they cannot be read by the processor. DRAM is used for main memory.

11. **dot pitch**- In a monitor, the vertical distance between the centers of like colored phosphors on the screen of a color monitor, measured in millimeters. The smaller the dot pitch, the finer the detail.

12. **dpi**- dots per inch. A measure of resolution expressed by the number of dots that a device can print or display in one inch.

13. **DSP**- digital signal processor. An integrated curcuit that typically performs complex operations on data

signals such as audio and video.

14. **E-IDE**- integrated development environment (enhanced). An improved version of IDE, which is a set of program-development tools that run from a single common user interface. Generally used to control hard drives and CD-ROM.

15. **graphics accelerator**- A specialized expansion board containing a graphics co-processor and other circuitry that provides text and graphics output to the monitor. Improves processing speed of graphics files or images.

16. **interpolation**- the process of introducing or inserting additional values between the existing values in a series. This process is frequently used in computer graphics.

17. **ISA**- industry standard architecture. An early architecture, it is a 16-bit bus design with a bandwidth of only 8MHz. The design is obsolescent and is considered a bottleneck.

18. **L1 cache**- cache that resides on the cpu.

19. **L2 cache**- cache that resides on the motherboard.

20. **monitor-** A video output device used to display text or graphics.

21. **motherboard-** The main printed circuit board in a computer that contains the CPU, appropriate coprocessor and support chips, device controllers, memory and also expansion slots to give access to the computer's internal bus.

22. **PB SRAM-** pipeline burst static RAM. PB SRAM employs input or output registers. This allows early access to the next address location yet still supplies data from the current location.

23. **PCI-** peripheral component interconnect. A specification introduced by *Intel* that defines a local bus that allows up to ten PCI- compliant cards to be plugged in to the computer.

24. **PDL-** page description language. The format in which the image information is transmitted from the PC to the printer.

25. **RAM-** random access memory. The main system memory in a computer, used for the operating system, application

programs and data.

26. **refresh rate-** In a monitor, the rate at which the phosphors that create the image on the screen, are refreshed.

27. **resolution-** The fineness of detail represented by any form of media.

28. **sample rate-** the rate at which analog signals are sampled and converted into digital data.

29. **scanner-** a data capture device that scans an object and creates a two-dimensional bit stream image of the object.

30. **SCSI-** small computer standard interface. A set of standards devised to control the way that peripheral devices are connected to a computer.

31. **SDRAM-** synchronous dynamic RAM. SDRAM is differentiated from DRAM because it can handle all input and output signals synchronized to the system clock.

32. **seek time-** the length of time required to move a disk drive's read/write head to a particular location on the disk.

33. **sound board-** an add-in expansion board that allows one to produce audio output of high quality recorded voice, music and sounds through headphones or external speakers.

34. **SRAM-** static random access memory. A type of computer memory that retains its contents as long as power is supplied; it does not need constant refreshing like DRAM therefore it is faster than DRAM but it cannot hold as much information. SRAM is used for cache memory.

35. **transfer rate-** the speed at which a disk drive can transfer information from the drive to the processor, usually measured in megabytes per second.

36. **USB-** universal serial bus. A newly developed bus for attaching monitors and other devices to a PC.

37. **video board-** a board designed to enhance a computers ability to manipulate video.

38. **video capture rate-** the rate at which an image is digitized.

39. **VLB-** VESA local bus. A 32-bit bus with a bandwidth of

either 33 or 40MHz.

40. **VRAM-** video random access memory. Special purpose RAM with two data paths for access which allows the VRAM to refresh the display and communicate with the computer all at once.

41. **wavetable synthesis-** a form of musical instrument digital interface (MIDI). It uses a store or table of digitally recorded instrument samples and blends them in a certain sequence to programmed music or sound effects.

42. **WRAM-** windows random access memory. WRAM optimized for use with a Windows based operating system.

**B. Software**

1. **authorware-** a program used to develop multimedia presentations that contain graphics, audio, text, animation and video elements.

2. **OS-** operating system. The software responsible for allocating system resources, including memory, processor time, disk space and peripheral devices.

3. **16-bit OS-** an operating system that deals with information 16 bits at a time.

4. **32-bit OS-** an operating system that deals with information 32 bits at a time.

**C. Image Processing Algorithms**

1. **JPEG-** Joint Photographic Experts Group. An image compression format for high quality, still images.

2. **MPEG-** Motion Picture Experts Group. An image compression standard and file format that defines a compression method for moving images such as desktop audio, animation and video.

3. **MPEG-1-** a standard that provides an image quality level analogous to that of the VHS standard.

4. **MPEG-2-** an increased quality standard analogous to a full-television quality standard.

## D. Other

1. **API-** application program interface. The complete set of operating system functions that an application can use to perform tasks such as managing files and displaying information on the computer screen.
2. **DirectDraw-** go-between for graphics hardware and video applications. Provides fast access to the acceleration features of 2D graphics chips.
3. **DirectSound-** uses hardware available in the computer to mix sounds and play them in real time.
4. **Direct3D-** works in conjunction with DirectDraw to provide direct access to 3D acceleration hardware.
5. **DirectVideo-** an adjunct piece of the DirectX set, DirectVideo provides a funnel for Video for Windows into DirectDraw.
6. **DirectX-** a family of API's developed by Microsoft.

7. **MPC Level 2-** multimedia personal computer level 2. A set of standards devised by the Multimedia PC Marketing Council. Level 2 requirements specify an 80486SX running at 25MHz, 8MB of memory, a hard disk with 160MB of free space, a double-speed CD-ROM capable of a 300K/second transfer rate and a 16-bit sound board.
8. **MPC Level 3-** an update of the Level 2 standard.

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